



September 1st, 2016

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RE: Magnetic Survey to locate abandoned wells DM-A and DM-B at Florence Copper Mine

A magnetic survey was completed by Chris Baldyga, Geophysicist for HGI on August 12th, 2016. This brief technical memorandum describes the logistics, procedures, and results of the magnetic investigation to locate two abandoned wells, DM-A and DM-B on the Florence Copper Site.

Method Description

Magnetometry is the study of the Earth's magnetic field and is the oldest branch of geophysics. The Earth's field is composed of three main parts:

1. Main field is internal (i.e., from a source within the Earth that varies slowly in time and space)
2. Secondary field is external to the Earth and varies rapidly in time
3. Small internal fields constant in time and space are caused by local magnetic anomalies in the near-surface crust.

Of interest to the geophysicist are the localized anomalies. These anomalies are either caused by magnetic minerals, mainly magnetite or pyrrhotite, or buried steel such as well casings and are the result of contrasts in the magnetic susceptibility (k) with respect to the background sediments. The average values for k are typically less than 1 for sedimentary formations and upwards to 20,000 for magnetite minerals.

The magnetic field is measured with a magnetometer. Magnetometers permit rapid, non-contact surveys to locate buried metallic objects and features. A one person portable field

unit can be used virtually anywhere a person can walk; although, they may be sensitive to local interferences, such as fences and overhead wires.

The magnetometer is used to measure the spatial variation of the Earth's field and may include various components (e.g., inclination, declination, and total intensity). A Novatel Smart VI antenna with sub-meter accuracy was equipped with Geometrics G859 magnetometer system to allow easier data collection without having to setup a local grid. Coordinates for the survey data were in UTM NAD 83 Zone 12. Readings are virtually continuous (5 per second) and results can be monitored in the field as the survey proceeds.

Data were subsequently downloaded in the field and checked for quality, then filtered, gridded, and plotted in the Tucson office using commercially available software.

Results

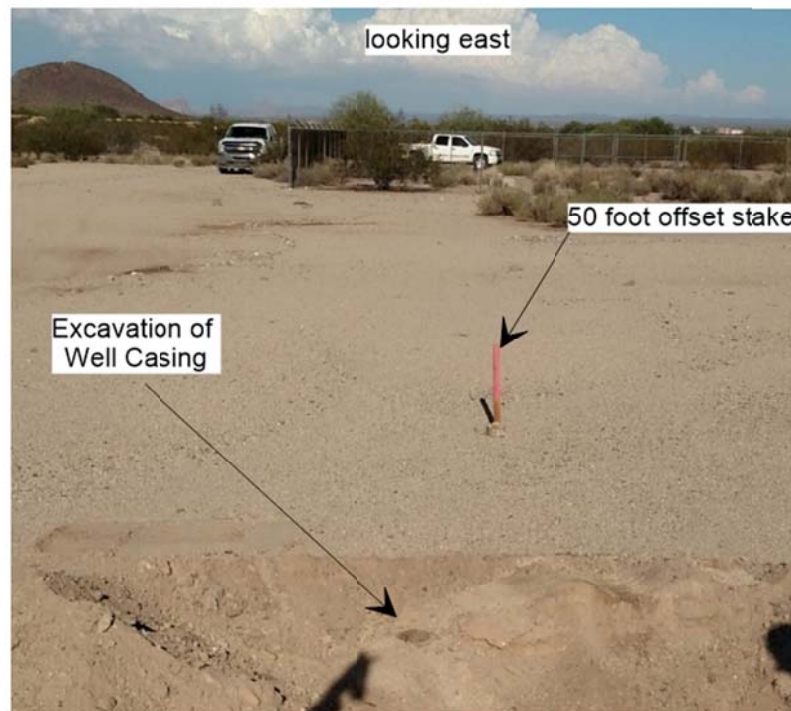
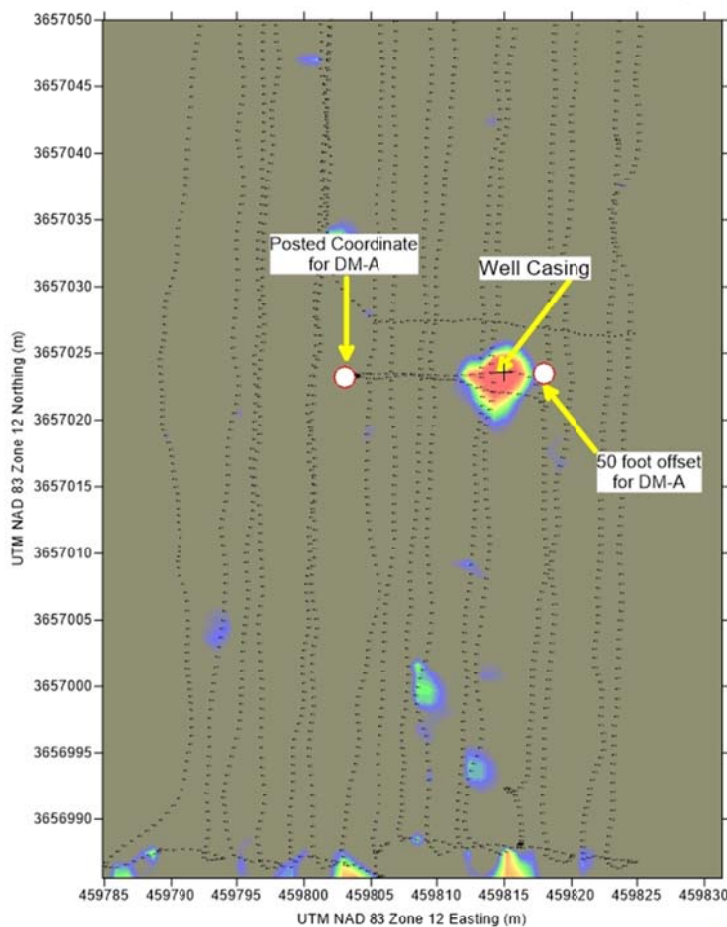
The first grid completed during the field work was to locate the well, DM-A. The ½ acre grid was centered on the reported location of the DM-A from the 1970's. Based on information provided to HGI by Florence Copper there is a 61 foot offset between the reported coordinate for DM-C well and its actual location. With this in mind the grid was setup to ensure adequate coverage to locate the DM-A well.

These two coordinates for the reported location of DM-A and its 50 foot offset are called out in Figure 1 to help spatially orient the reader.

The contoured results in Figure 1 show a very high amplitude anomaly that was located about 40 feet east of the reported coordinates for DM-A. While HGI was on-site, Florence Copper personnel were able to excavate around this location and revealed a surface collar. The photo included in Figure 1 shows the exposed well casing. The location of the casing that was discovered corresponds to core hole 139S. Core hole 139S was constructed in 1972 and the records indicate that the casing was 5 inch at the surface, matching what was observed in the field.

Figure 1

Total Field Magnetic Results near DM-A



**Florence Copper Mine
Magnetic Survey**

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Figure 1

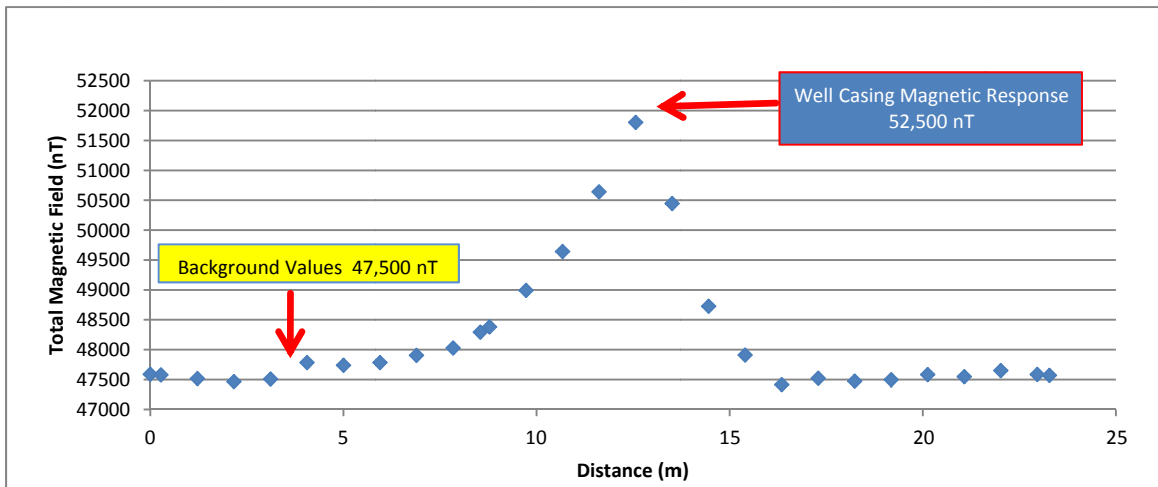
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Figure 2 shows the profile of the magnetic field values across the confirmed well casing near DM-A.

Figure 2 – Magnetic profile across confirmed well casing near DM-A



The major takeaway features in Figure 2 is to note the background values of about 47,500 nanoTeslas (nT) and the peak amplitude from the well casing of 52,000 nT or about 5,000 nT above background values. This will help serve as a benchmark in the discussion of results for DM-B.

Figure 3 shows the contoured results to locate the well, DM-B. Within this survey area is an exposed steel cased core hole, 149S, which provided a similar high amplitude response as observed for 139-S. Figure 4 shows a similar 2-dimensional profile across the 149S well casing in which the peak response is about 49,400 nT or about 2,000 nT above background responses.

The same dynamic color range was used for both contour plots for the areas around 149S and 139S to purposely emphasize responses due to steel cased well and de-emphasize scrap metal on the surface. In Figure 4, the reported locations for DM-B and the 60 foot offset are shown to provide a spatial reference for the reader. Near these areas it is clear that there are no other high amplitude responses within the survey grid area. A 4 foot section of scrap steel casing was buried about 4 feet below the ground to act as a calibration point and is noted in Figure 3 and was detectable relative to background values. Based on the results there are no recommended areas for excavation to uncover the DM-B well location.

Figure 3

Total Field Magnetic Results for DM-B

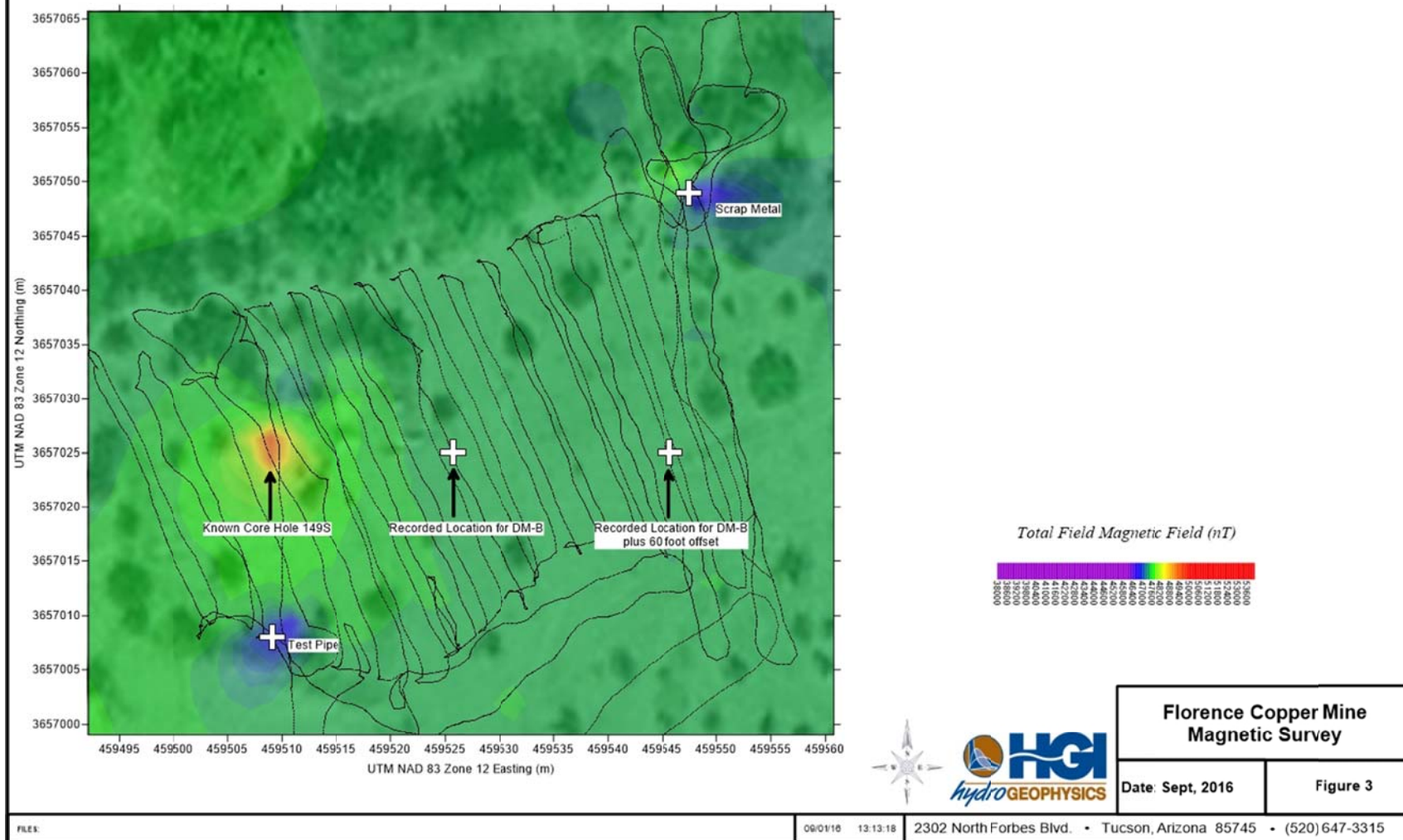
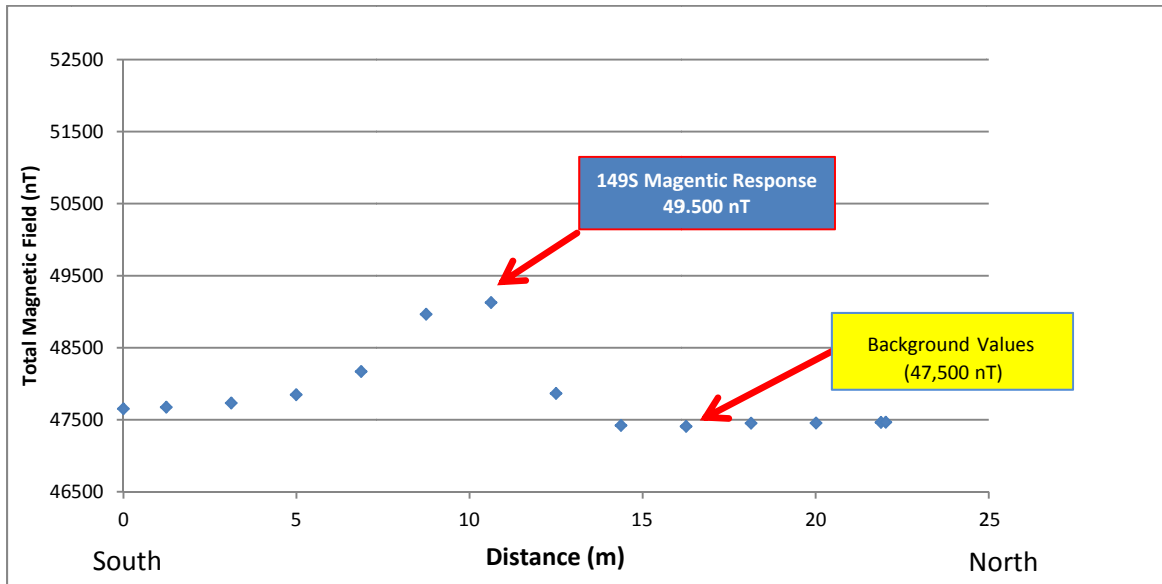


Figure 4 – Magnetic profile across core hole 149S



Conclusions

Based on the observed responses from the magnetic survey the steel cased well, 139S, was associated with a high amplitude response (5,000 nT) and excavated on the day HGI was on-site. DM-A was not located. The data collected around the reported location for DM-B did not reveal any high amplitude anomalies but only small variation of less than 100 nT above or below background values. The only high amplitude responses were over the known core hole, 149S, showing a 2,000 nT increase from background and a piece of 4 foot steel casing buried about 4 feet.

The results reported herein are valid within the limits of the coverage and the resolution of the methods used.

June 30th, 2016

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RE: EM Survey to locate abandoned well DM-B at Florence Copper Mine

This brief technical memorandum describes the logistics, procedures, and results of the electromagnetic (EM) investigation to locate an abandoned well, DM-B on the Florence Copper Site.

Logistics

An EM survey was completed by Chris Baldyga and Shawn Calendine, Geophysicists for HGI on June 21st, 2016. A grid was established using measuring chains, with data collected at 10 – foot line separations in an N-S bidirectional manner. The grid dimensions were chosen to encompass the assumed location of the abandoned well, DM-9.

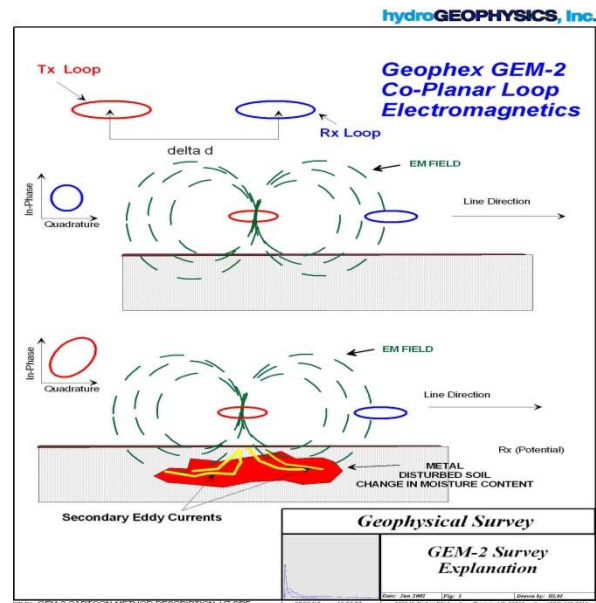
A Geophex GEM-2 terrain conductivity instrument was used for data acquisition. This instrument is a shoulder carried, digital, co-planar, multi-frequency EM instrument. Data are collected and stored in the control unit.

Data were subsequently downloaded in the field and checked for quality, then filtered, kriged, gridded, and plotted in the Tucson office using commercially available software.

The survey origin was established at the Southwest corner of the study grid. All units are in feet.

Method Description

Electromagnetic field data are typically collected using portable ground conductivity instrumentation. A transmitting coil induces an electromagnetic field and a receiving coil at a (usually) fixed separation measures the amplitudes of the in-phase and quadrature components of the electromagnetic field. Various instruments have different coil spacings and operating frequencies. Spacing and frequency affect depth of signal penetration. Both single frequency and multi-frequency instruments have been developed for commercial use.



Schematic 1: GEM-2 instrument explanation.

The recorded electromagnetic field is separable into two sub-components; in-phase and conductivity (also referred to as quadrature). The in-phase component is most sensitive to metallic objects and is measured in parts per million (ppm). The quadrature component is sensitive to soil condition variations and is measured – for the GEM-2 instrument – in milli-siemens/meter (mS/m)

The EM method was chosen due to the capability of mapping changes in soil conductivity that are caused by changes in soil moisture, disruption, or other conductivity changes caused by physical property contrasts, for its the ability to detect metallic objects (both ferrous and non-ferrous), and due to the relatively rapid rate of data acquisition.

Results

In order to discriminate the differences between features the contoured results are shown with a color scale chosen using a histogram of the entire dataset such that the background values in undisturbed areas is designated to be a green color. Any anomalous features higher than these limits will be observed as either red, dark brown or dark purple. It should be noted that the orientation of the EM sensors relative to the target can create a

positive or negative anomaly over a highly metallic object depending on orientation of EM sensor and geometry of buried features. Smaller pieces of fragment metal will appear as background colors greenish to bluish hues.

Figures 1 show the results for the in-phase at 3 kHz. This frequency was chosen to help discern the deepest features. The higher frequency data were evaluated but are more representative of shallow metallic objects. Background values range in the area of 300 ppm. The existing core boring is seen in the contour plot and shows us that it has a reversed polarity response (negative). Using this as a guide there are several other responses that could be related to the buried well. It is suggested that these areas be uncovered. Anomaly #1 is of specific interest due to its response being very similar to the known steel cased core boring.

Anomaly #	Easting (ft)	Northing (ft)
1	30	88
2	140	68
3	140	45
4	140	15

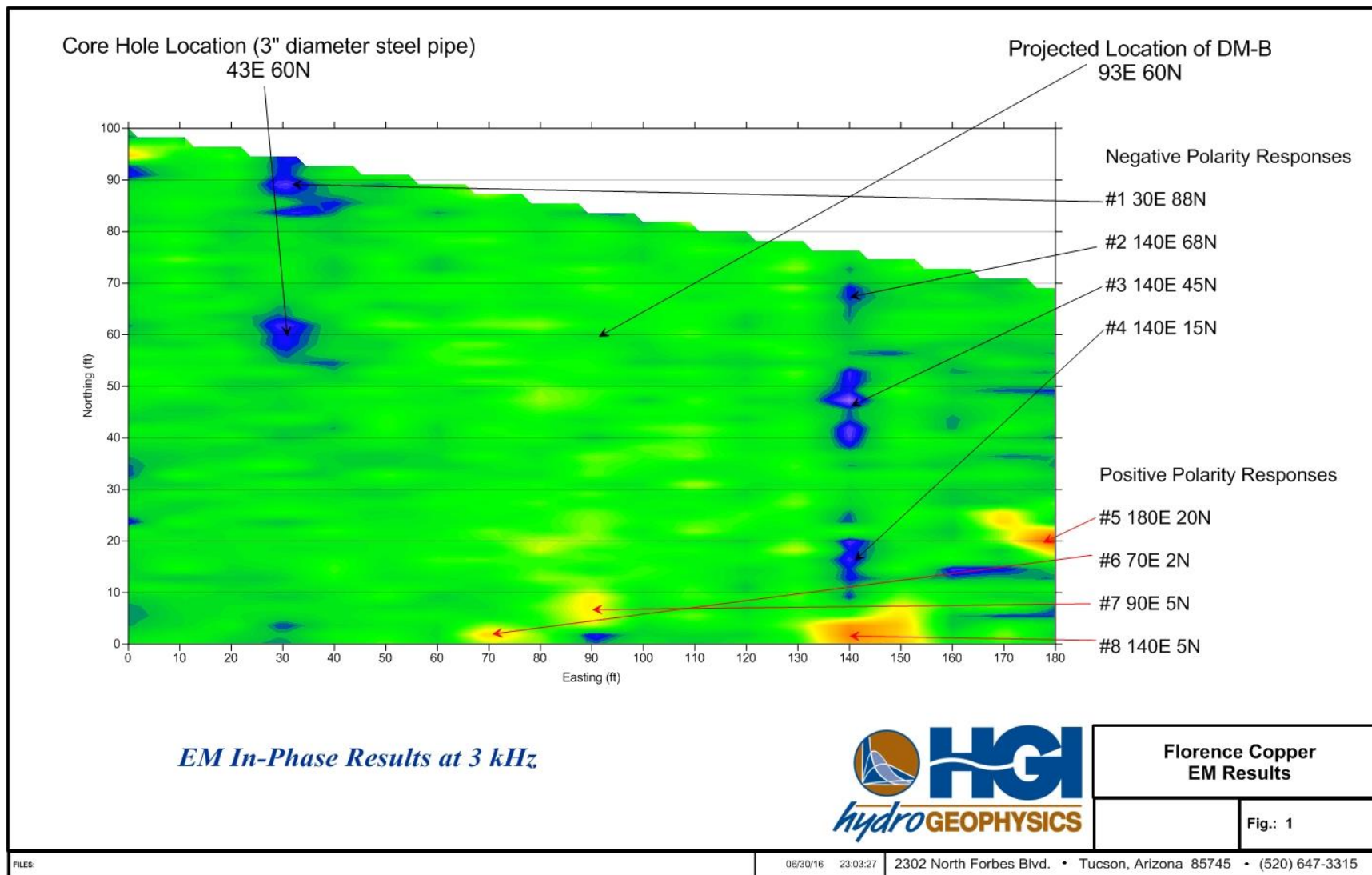
Table 1 shows the locations of the negative responses in Grid 1.

There are several positive amplitude anomalies also worth investigating and are shown in Table 2. Anomaly # 5 is likely due to surface debris noted in the field. The highest amplitude anomaly is #8 and is of specific interest during the excavation process.

Anomaly #	Easting (ft)	Northing (ft)
5	180	20
6	70	2
7	90	5
8	140	5

Table 2 shows the locations of the positive responses in Grid 1.

Figure 1. EM Survey results with 3 K In-phase component



Conclusions & Recommendations

Based on the contoured geophysical results, the observed responses show relatively subtle amplitudes that may be indicative of a buried abandoned well. Excavation is recommended on the noted anomalies. If the excavation efforts do not reveal the location of the buried well then the next geophysical method to possibly help locate the well would be the magnetic method utilizing a system equivalent to the G-859 magnetometer by Geometrics.

The results reported herein are valid within the limits of the coverage and the resolution of the methods used.